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BUREAU OF LAND MANAGEMENT

MISSOURI RIVER BASIN INVESTIGATIONS

LAND PLANNING AND CLASSIFICATION REPORT FOR BOYSEN AREA, WYOMING (SHOSHONE BASIN)

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ACKNOWLEDGMENTS

This report is largely a re-compilation of factual data gathered from many and various reports and sources. The objective has been to assemble together into one report as much of the pertinent factual information as could be gathered in reasonable time, and with reasonable research and investigation to provide for a sound basis and serve as a guide for developing plans and formulating policies for the future use and management of the remaining unreserved, unappropriated public lands affected by and within the influence of the projected Boysen Reservoir.

Our sources of information include: records of the former General Land Office and Grazing Service; published reports by State Engineer, State Geologist, State Extension Service, State Experiment Station, and other offices and departments of the State of Wyoming; U. S. Weather Bureau, Bureau of Reclamation, Bureau of Indian Affairs, Fish and Wildlife Service, Geological Survey, Bureau of Mines, Soil Conservation Service, Forest Service, Production and Marketing Administration, Bureau of Agricultural Economics, U. S. Corps of Engineers, and other Federal offices and departments; County records and the yet clear memory of many local longtime residents of the area.

The assembling of these data and the gathering of pertinent information by field reconnaissance and the final preparation of the maps and reports has been a group effort by the Bureau of Land Management staff working on the Land Planning and Classification phase of our Missouri River Basin Investigations. Those participating were Fred M. Benson and Ned Smith, range examiners who conducted most of the field surveys; Elmer D. Hunter checked land status records; Albert Shunk and Ruth Hatveldt drafted the maps and Harold T. Jorgenson and Robert D. Nielson, land economists, prepared and edited the report.

Special mention should be made of the assistance of Professor T. J. Dunnewald, Department of Agronomy, University of Wyoming, and Harold Bendschalder, Soil Scientist, Soil Conservation Service, in providing information regarding soils; of the cooperation of Kenneth R. Melin, Geologist, U. S. Geological Survey, in describing the geology of the area; and of assistance rendered by Edward Hill, District Grazier, Wyoming Grazing District No. 2 in furnishing data on range resources, uses and problems.

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PURPOSE AND SCOPE

This report endeavors to present the broad physical and economic features of the area tributary to the projected Boysen Reservoir (Shoshone Basin) as a guide in orienting the land classification and planning activities of the Bureau of Land Management on nearly 1,344,000 acres of public domain as a step in the furtherance of the Missouri River Basin development program. It is a generalized introductory and preliminary report subject to revision in accordance with the findings of more thorough localized investigation. As preparation for subsequent more intensive work it establishes and maps, in addition, the status and location of all public lands to provide an inventory of these lands and directs attention to the principal land use and land management problems prevailing in the area as a whole and in the natural planning sub-area units in those sections in which the public domain lands are concentrated.

The approach used in attaining this purpose and presenting the results have been historical, analytical, descriptive, and graphic. Settlement of the basin and development of its economy have been studied; the influence of the physical, biologic, economic, and public land program factors which have been and now are instrumental in shaping land use have been appraised; and the recognized land use and land management problems which have emerged have been summarized and related to their present and future effects on human welfare.

This study and detailed studies which will follow it on sub-areas of the basin are based on a belief in Man's ability to cope successfully with the challenge of a difficult natural environment once all the facts are faced. It is important to face these facts and accept the challenge if we are to create the particular kind of production and social services to which the area is uniquely suited and by which it can contribute most to the larger life of a great river valley and a strong nation.

SUMMARY

Tributary area of projected Boysen Reservoir coincides with Shoshone Basin and contains approximately 8,000 square miles. It is hemmed in by the high Shoshone Mountains and the lower arch of the Owl Creek, Bridger and Bighorn Mountains on the north and lofty Wind River Range, steep Sweetwater Plateau rim, and Rattlesnake Mountains in the southwest and south. The floor of the basin consists of a broad undulating plateau comprised of highly erodible shales, brown sandstones, and coarse conglomerates which is broken in many places by rough ridges, prominent mesas or buttes, and in places badlands. It is dissected by numerous deeply eroded washes and stream courses, the main streams and larger tributaries having quite extensive flood plains and terraces containing fertile irrigable soils.

Drainage waters gathered by upper tributaries of Bighorn River are the life blood of this semi-desert area. The primary need is to obtain as much water as possible for irrigation with a minimum of erosion and silting. Most of the run-off is from melting snows and glaciers and from the more elevated and moister western and southern parts of the basin. Flood control is not a paramount problem as great general storms causing extensive flooding are of rare occurrence. The region's most destructive flood which occurred in July 1923, however, caused over one million dollars of damage.

Physiographic deterioration of the basin's drainage system contributes to the excessive silting of Bighorn River which carries the heaviest silt load of any major tributary of the Missouri River system. It is most evident in the silt-clogged channels, enlarged and sandy washes, cut stream banks, and rapid extension of gully networks in Five Mile Creek, Muddy Creek, Badwater Creek, Muskrat Creek and Beaver Creek. The normal silt load received from the basin is estimated to be about 4,404 acre feet per year.

Climate restricts agricultural land use almost entirely to irrigation farming and livestock enterprises. Rainfall averages from 7.62 inches annually in the near-desert area about Shoshoni to over 20 inches in the high mountains. During the spring and early summer rainy season, occasional beating rains occur which produce excessive run-off of great eroding power on the fine sparsely vegetated or denuded soils.

Prevalence of swift run-off, localized watershed impairment, and excessive silting of Bighorn River are attributable mainly to widespread deterioration and in some places outright destruction of native vegetation during the past sixty years. On most range lands the thin vegetative cover is gradually improving, however, and is now in fair condition as a result of widely applied improved grazing practices and prevalence of above normal rainfall in recent years. Nevertheless, in certain localities, notably in Badwater watershed, forage still remains in generally poor condition and in some places it is virtually exterminated due to overstocking, unseasonal use, and excessive sheep trailing. Valuable grasses on much of the range have been partly replaced by economically inferior or worthless grasses, half shrubs, and annual weeds. In general, shortgrass with a sagebrush aspect occupies the lower and more arid basin floor areas; bunch grasses, shrubs, and open dwarfed woodlands occur on mountain foothills, buttes, and rocky ridges; and true forests or mountain brush clothe mountain slopes between the foothills and the alpine grasses and sedges above timberline.

Except in localized areas where lands have been most misused, soil erosion is only slight to moderate. On the whole, water erosion is more injurious and widespread than wind erosion. On lands under custody of the Bureau of Land Management, Badwater Creek watershed with its widespread forage depletion evinces the most critical wind and water erosion. In upper Muskrat Creek, occasional gullies occur and intermittent streams during flood periods carry considerable silt. In Poison Creek drainage, many intermittent tributaries and the main channel contribute moderate amounts of silt if precipitation is heavy and several sand dune areas continue to be active. Severe gully erosion at the heads of Beaver and Hall Creeks appear to be slowly healing as a result of range management and reduction of grazing in the area. Erosion conditions are generally moderate in upper Wind River watershed about Dubois. On other lands, most serious erosion occurs along Five Mile Creek where the channel has been deepened and the sides sloughed primarily by waste irrigation water. Lower Wind River and Little Wind River area was designated as a critical erosion area by the U. S. Department of Agriculture erosion survey in 1935. If silt losses are detracted evenly overthe entire basin surface, soil and parent material damages are going on at the rate of more than one acre-foot each year for every two square miles. Erosion on such a scale is symptomatic of disrupted natural harmonies which, if unattended, threaten to cause even more serious and widespread land breakdown.

Approximately 16,000 people live in the basin. The population increased about 5,600 between 1930 and 1940 and an even greater increase may attend the expansion of the Riverton Irrigation Project. Expected population growth need not increase destructive pressures on the land. The population is nearly half rural-farm, about one-third urban, and the remainder rural non-farm.

Land ownership and control strongly influence land management and the improvement which can be made in management. Of approximately 5,120,000 acres in the basin, about 28.9 per cent lies within Wyoming Grazing District No. 2, 44.3 per cent within the diminished and ceded portion of Wind River Indian Reservation, 16.2 per cent within Washakie National Forest, 4.3 per cent within Riverton Irrigation Project, and 5.8 per cent in four separate nuclei of public domain outside of established land management program areas. State lands and private lands on which limited or no conservation controls can be directly exercised by the Federal government are interspersed within the managed and unmanaged areas and total 208,978 acres and about 500,000 acres, respectively. About 1,343,935 acres are under custody of the Bureau of Land Management. This includes approximately 1,044,960 acres of grazing district lands and 298,975 acres of public domain in various status categories. Land use and land administration problems exist in northwest Natrona County, southeast Hot Springs County, central Popo Agie watershed, and upper Wind River areas because of the checkered pattern of Federal, state, and private ownership.

Irrigated lands in 1940 totalled 110,900 acres of which 42,500 acres lay in the Riverton Project. Authorized further development of irrigable lands in this project will add 57,500 acres, or 52 per cent to the irrigated acreage. Proposed future additional irrigation developments would eventually expand the irrigated area by a total of 99,500 acres, or 90 per cent.

Effective integration of the increase in irrigated crop production with the range livestock industry can serve to alleviate locally the strain on range resources.

Shoshone basin is primarily an agricultural area devoted mainly to production of range cattle and sheep. Arable and irrigated lands comprise only slightly more than 4 per cent of the total area. Virtually all crops are grown under irrigation and most of them are closely related to the livestock industry. Of the 89,800 acres harvested in 1939, hay crops comprised 56 per cent; small grain 24 per cent; sugar beets, dry beans, corn, and potato row crops 12 per cent; and vegetables, berries, melons, and other minor crops 8 per cent. Stock, general, and crop specialty types of farms prevail in the Lander-Fort Washakie-Riverton irrigated crop-producing area.

About 90 per cent of all land is used mainly for grazing. Both cattle and sheep graze on the open range. In April 1940, there was an estimated 104, 230 animal units owned in the basin consisting of 83,730 animal units of sheep and beef cattle and 20,500 other animal units of essentially non-range livestock, including poultry. On grazing lands in the eastern and southern portions of the basin where only small and widely scattered irrigable tracts provide crop production opportunities, principally hay, sheep ranches predominate. In the upper western portions where enough irrigated hay can be grown to supplement spring and fall range forage and carry cattle throughout the winter, cattle ranching predominates, although sheep grazing is important. Death losses resulting from drought, overstocking the range during good years, severe storms at shearing and lambing time, deep snows and blizzards during the winter and early spring, poisonous plants, predatory animals, and straying run comparatively high.

With development of additional irrigated forage-producing land, the feeding and fattening of livestock for market should increase. Increased feed producing capacity of irrigated lands, however, should be balanced with increased cheap forage on open ranges. The range land, like farm land, can be made to produce more by adequate improvement and development.

Farm and ranch lands provide direct employment to 2,300 people, nearly half of the working population. These workers and the much smaller numbers in the mineral and forest industries may be considered the basic employment group. Tourism and "guest ranching", however, is a rapidly growing industry. While the economy can be expanded by fuller development of the mineral and recreational resources and more complete processingof forest and agricultural output, the most substantial development will attend the application of unused waters to arable dry lands and the improvement and development of the range lands.

There are five principal land problems in the basin:

1. Prevention of land and river breakdown.
2. Provision of maximum watershed services.
3. Integration of irrigated and range land uses.
4. Reduction of range livestock hazards.
5. Provision of efficient and economical administration of public domain lands.

In the land classification and land planning investigations seeking solution to these and other land management problems the Bureau of Land Management will concentrate intensive work in the three sub-areas: Badwater Sub-area, Muskrat-Beaver Creeks Sub-area, and Dubois Sub-area.

GENERAL DESCRIPTION

The area tributary to the projected Boysen Reservoir is a structural and drainage basin high among the middle Rocky Mountains in west central Wyoming. The area is roughly semicircular in shape and contains approximately 8,000 square miles. Maximum dimensions are about 145 miles from east to west and about 55 miles from north to south. All but a small part in the northeast lies within Fremont County.

Mountains fringe the area on all sides except the southeast and east; those in the west and southwest forming part of the Continental Divide. The broad upland prairie between the surrounding mountains is undulating and broken and, as the rainfall is scanty, it supports only a sparce desert-like vegetation. Drainage waters gathered by the upper tributaries of Bighorn River are the life blood of the area. Inherently fertile soils on irrigable level benches and terraces or on alluvial fans and valley fill produce abundantly when supplied with enough water. On the whole, the higher unirragable grassland soils are capable of producing a good quality of forage for livestock and big game.

The land economy is largely built on grass and irrigation water. Stockmen came into this country in the early seventies after the Indians were confined to reservations. The first few irrigators settled in the Lander area as early as the late sixties. Fortunately, settlement and irrigation proceeded simultaneously. Irrigation, practiced both on a grand scale as in the Riverton Irrigation Project and in a "shoe string" manner as an adjunct to general ranching, embraced 110,900 acres in 1940. Virtually all crop production is from irrigated land and most of it is closely related to the livestock industry.

Farm and ranch lands provide direct employment to 2,300 people, nearly half of the working population. These workers and the much smaller numbers in the mineral and forest industries may be considered the basic employment group. Without them there would be little to sell, ship, or manufacture and there would be a scant market for goods and services. Tourism and "guest ranching", however, is a rapidly growing industry. While the economy can be expanded by fuller development of the mineral and recreational resources and more complete processing of the forest and agricultural output, especially with provision of additional cheap hydro-electric power, the most substantial development will attend the application of unused waters to arable dry lands and the improvement and fuller utilization of the grasslands.

Utilization and development of water and grasslands is highly interrelated. Of the two, grasslands are most rudimentary to resources development as here they are the key to water control and land control and a mainstay in regional synthesis.

To a large extent, utilization of other resources involves a determination of the proper use of grassland and water resources. To see the whole job of land management, though, it is necessary to view the salient features of the entire physical and economic framework of the basin. This involves the physiographic layout, climatic features, distribution and vigor of natural vegetation, soil conditions and losses, human occupance, land ownership and control, land uses, and industrial development.

PHYSIOGRAPHY

The drainage area of the Boysen Reservoir coincides with the Shoshone Basin 1/. It constitutes one of a number of more or less subordinate basins which together comprise the large Wyoming Basin sag in the Middle Rocky Mountains. Structurally, it is a long trough between the towering Shosone Mountains and the lower arch of the Owl Creek, Bridger, and Bighorn Mountains on the north and the lofty Wind River Range, the high and steep Sweetwater Plateau Rim, and the Rattlesnake Mountains on the southwest and south (Figure 1). On the east side, south of the Bighorn Mountains, the drainage divide is naturally present between the Powder River watershed and Shoshone Basin but structurally it is not so evident.

The floor of the basin, by far the larger part of the Boysen Reservoir watershed, is a broad plateau which rises from less than 5,000 feet along the Bighorn River to a general height of about 6,000 feet along its margins except in the narrow northwest extension where it attains over 7,000 feet. Through an opening between the southern end of Bighorn Range and the upfold of strata called "Oil Mountain Anticline" the basin floor is more or less continuous with the Great Plains.

In the following, the physiography is discussed by structural features which constitute quite distinct geographic units. Unfortunately, no detailed topographic maps are available which show the complete relief of this basin.

Basin Slope of Owl Creek-Bridger-Bighorn Ranges.

Owl Creek, Bridger, and the southern extension of the Bighorn Mountains are parts of a huge structural uplift extending west to east 2/.

1/ This name is taken from the "Reconnaissance Geological Map of Wyoming" by Wilbur C. Knight, University of Wyoming, about 1901. The more commonly used name, "Wind River Basin", more properly belongs to the western half of this basin. Nevin M. Fenneman in "Physiography of Western United States" (1931) used the name Shoshone Basin.

2/ Darton, N. H., Geology of the Owl Creek Mountains, with notes on resources of adjoining regions in the ceded portion of the Shoshone Indian Reservation, Wyoming: U. S. 59th Congress, 1st Sess., Sen. Doc. 219, p. 26, 1906.

The Owl Creek and Bridger Ranges rise somewhat higher than the Bighorn Mountains and are separated from it by a low saddle in the vicinity of Bridger Creek. The mountain summits generally vary from about 7,000 to 9,500 feet in altitude. Black Mountain, an outlying peak reaching 10,165 feet in western Owl Creek Range, resulted from local doming. In Owl Creek Mountains, the folding and subsequent erosion resulted in a diagonal series of ridges trending northwest-southeast across the main axis of the range.

In each range, large areas of pre-Cambrian granite, gneiss and schists have been exposed by erosion of overlying strata. A thick series of Paleozoic and Mesozoic sedimentary rocks lifted by arching of the ranges and truncated by erosion lays upon the mountain flanks. Many miles from the base of the mountains, the more resistant of these tilted and eroded sedimentary beds first begin to form low broken ridges parallel to the trend of the mountains. Late Paleozoic Phosphoria formation of limestone, shale, sandstone and chert forms great dip slopes on the mountain flanks, especially on either side of the Bighorn River canyon. Outlying remnants of the Tertiary rocks of the basin floor still remain high in Bridger Creek sag.

Basin Slope of Wind River Range.

The backbone of the uplifted northwest-southeast trending Wind River Range consists of pre-Cambrian granodiorites and metamorphics which form the higher parts of the range and the glaciated peaks which rise to a maximum elevation of 13,785 feet. Paleozoic sediments on the northeast side form high foothills with the more resistant beds of the Phosphoria formation constituting long dip slopes ranging from one-half to two miles long.

The outer and lower foothills are caused by a long fold on the flank of the mountains, the fold consisting of a series of elongated domes located end to end with Mesozoic strata lapping quite steeply onto the northeast and southwest flanks. 3/ Southwest of the intervening, comparatively narrow, structural dip, sedimentary strata rise again on the sides of Wind River Range. A thick series of alternating formations of mainly sandstones and shales underlie the ridges and longitudinal valleys paralleling the axis of the range. Mountain glaciers during late Pleistocene moved down through the canyons and in the northwestern portion of the range extended out onto the margin of the floor of the basin. Along the glaciated valleys numerous small recessional moraines occur, many of which serve to dam up mountain lakes.

Shoshone Basin Floor.

The landscape of the basin floor appears as an undulating plain broken in many places by rough stony ridges, prominent level-topped mesas, and narrow stream valleys with their attendant alluvial terraces and bottom lands. The floor is underlain by an extensive succession of sedimentary rocks resting uncomfortably upon the pre-Cambrian basement complex and comprising mainly sandstones, shales, dolomites, limestones, and lesser amounts of siltstones and conglomerates.

3/ Bauer, C. M., Wind River Basin: Geol. Soc. America Bull., vol. 45., p. 684, 1934.

Lower Eocene strata of the Wind River formation which consists generally of weak variegated shales, brown arkosic sandstones, and coarse conglomerates originating from stream deposition extends over all but the margins of the basin floor and its northwestern extension above Lenora where the later but lithologically similar Wasatch formation prevails. Over large areas the strata lie almost horizontal, the weaker members being generally well peneplained while the more resistant beds remain as flattish "benches" slightly above the general level. Where dip slopes occur, and they are common as the strata have been locally warped, low escarpments or ridges have been sculptured. The general plains level west of Bighorn River slopes an average of about 30 to 40 feet per mile in an easterly direction. Dip of the lentils commonly conforms to or exceeds this dip.

East of lower Wind River, an extensive, elevated, gravel-covered plain features the landscape. In Poison Creek watershed, in Townships 37 North, Ranges 91 and 92 West, a sizeable area of sand dunes exists. Considerable areas of badlands occur, so-called because of severe erosion and almost complete absence of vegetation. Some of them obtain in unreduced cuestas or on the margins of buttes and mesas and others near streams trenching the general level. Badlands prevail along much of the Badwater-Poison Creek divide from Bonneville eastward nearly to Natrona County. There are also several small areas of badlands in Badwater watershed east of Bridger Creek. The badland area southeast of Poposia is carved from a series of shales, unconsolidated arkosic sands, and a local band of white tuff. Above Crow Creek, the Wind River watershed consists of a succession of rocky-sided valleys separated by ridges in part broken into badlands. The interstream area between Muddy and Five Mile Creeks south of Bargee in T. 6 N., R. 1 W., T. 6 N., R. 1 E., and T. 5 N., R. 1 E., Wind River Meridian is an extensive area of wasteland. North of Sweetwater rim which generally rises 600 to 800 feet above the general level of the basin floor and extends northeastward and eastward for about 53 miles to join the Rattlesnake Mountains, there are several en echelon structural folds which form Sand Draw, Alkali Butte, Conant Creek, Muskrat Creek, and Dutton Dome from which Tertiary strata have been removed, exposing the Mesozoic sedimentaries. Extensive Lost Wells Butte rises above the irrigated lands of Riverton Project.

Basin Slope of Shoshone Mountains.

The high steep southern end of Absaroka Range, called the Shoshone Mountains, bounds the area in the northwest. Built largely of volcanic accumulations, mostly breccias, the mountains join and overlap the western end of Owl Creek Range. Relief is extremely varied in character with mountains sculptured from volcanic rocks, bold granite and steeply dipping sedimentary ridges, basin-like depressions carved in non-resistant sediments, broad entrenched flood plains, prominent mesa-forming remnant pediments, and steep-walled canyons in places flanked by pinnacles, spires, and castellated remnants constituting the most conspicuous land forms represented. 4/ Washakie Needles attain an altitude of 12,496 feet. East Fork of North Fork of Wind River has cut a canyon 500 feet deep in this area.

4/ Love, David, The geology of the western end of the Owl Creek Mountains, Wyoming, Geology Survey of Wyoming, p. 22.

Drainage and Water Supply

Drainage is gathered by the headwater tributaries of the Bighorn River which forms at the confluence of the Wind and Popo Agie Rivers and flows north out of the basin through a magnificent canyon cut 2,250 feet deep between the Owl Creek and Bridger Mountain ranges. The basin contains the second and third largest tributaries of the Bighorn River, namely Wind River and Popo Agie River, and contributes more than 40 percent of the total run-off of the main stream where it joins the Yellowstone River.

The greater part of the run-off of the Bighorn River is from melting mountain snows and from the more elevated and moister western and southern parts of the basin. Few of the minor headwaters in other portions are continuously live streams from their source to their mouth. Occasional heavy downpours cause some of these streams which generally are merely wide sandy washes most of the time to become torrents of mud. Perennial streams of the basin are reported to carry little sediment during the greater part of the year, but a slight rain causes the water to become muddy, and the torrential rains which occur principally in the spring and summer cause a great amount of washing and often cut deep gullies in a few hours. 5/

Water for Riverton Reclamation Project comes from the Wind River and its tributaries, storage being provided by Bull Lake Reservoir (152,000 acre feet) and Pilot Butte Reservoir (31,500 acre feet). The project has suffered no water shortage to date, and Bureau of Reclamation water supply studies show that under ultimate development to 100,000 acres there would have been only shortages of 10 per cent in 1934, 5 per cent in 1939, and 35 per cent in 1940. In Popo Agie watershed there are three storage reservoirs with total storage capacity of 6,350 acre feet which supply supplemental water to the Enterprise, Little Popo Agie, and North Fork Popo Agie irrigation districts. Available information and opinion of local residents indicate that there is a shortage of water during the latter part of the irrigation season and consequent sub-optimum use or irrigated lands in some of these smaller streams. 6/. However, there is considerable wasteage of irrigation water earlier in the season. There is enough run-off during spring months to satisfy all irrigation demands and provide the increased storage in improved facilities to supply sufficient water during periods of inadequate stream flow for irrigated lands both within and without the irrigation districts. Indian Service lands depend almost entirely on direct-flow diversions from the streams. Washakie and Ray Lake reservoirs in the Little Wind River watershed with a total capacity of 15,000 acre feet provide storage for Indian Reservation lands.

The Bureau of Reclamation has proposed the development of five additional reservoirs in the basin, at Du Noir on the main Wind River, at Raft Lake, Sorrel Creek, Onion Flat, and Badwater Creek with a total aggregate capacity

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5/ Op. Cit., Bauer, C. M., pp. 682-3.

6/ Water facilities for Popo Agie Drainage Basin, Fremont County, Wyoming: U. S. Dept. Agr., Water Utilization Section, Div. Land Economics, p. 19. 1939.

of 302,500 acre feet, of which the Du Noir Reservoir will have 220,000 acre feet. 7/

Geological and hydrological conditions, together with existing well logs and lay opinion, indicate that a satisfactory supply of ground water in amounts adequate for domestic and livestock needs should be recoverable with proper well construction in most parts of the basin from depths seldom exceeding 200 feet. The extensive use of ground water for irrigation does not appear economically feasible in the basin. Lander and Riverton, the two largest communities in the area, pump their water supplies from wells.

Floods

Flood control is not a paramount problem in the basin as great general storms covering the entire area are of rare occurrence. Flood damages in the entire Bighorn River valley ranging between fifteen to ninety-five thousand dollars have been recorded on but six occasions beginning with 1908. The destructive flood of July 1923, however, caused $1,800,000 in damages.8/ Minor flood damage in localized areas occurs where streams of the range lands, especially those with watersheds widely depleted of vegetative cover, respond quickly to cloudburst rains. Badwater Creek especially lived up to its name in the disaster of 1923, when it was the center of the prolonged heavy rainfall which caused the basin's most damaging flood. Economic damages resulting from this flood have been summarized as follows:

> "The flood caused the greatest damage along Badwater Creek and below the mouth of the Badwater as far as the head of the Big Horn Canyon. In this stretch the Chicago, Burlington & Quincy Railroad had 20 miles of track washed out, of which about 8 miles was subsequently relocated away from the river bottom. Three steel bridges were destroyed. The entire town of Bonneville was covered with 2 to 5 feet of water. Several buildings and 10 freight cars were washed downstream, and additional buildings were wrecked. Just east of the railroad station, where the railroad formerly crossed Badwater Creek on a 120-foot steel bridge, the channel is now more than 300 feet wide. In front of the station the 80-foot channel was widened to 500 feet. The loss to the railroad alone was estimated at more than $1,000,000." 9/

Physiographic Deterioration and Siltation

Geologic erosion has plainly been revived since the last erosion surface was made. Nevertheless, much of the erosion caused by excessive run-off

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7/ Missouri River Basin, conservation, control, and use; Sen. Doc. 191, 78th Congress, 2nd Sess., p. 49, 1944.

8/ Yellowstone River, Wyoming, Montana, and North Dakota: 73rd Cong., 2nd Sess., H. Doc. 256, 1934.

9/ Follansbee, Robert, and Hodges, P. V., Some floods in the Rocky Mountain Region: U. S. Geol. Survey Water-Supply Paper 520-G., p. 110, 1925.

of storm periods is traceable to depleted grassland areas of the basin floor and overgrazed pinon and juniper woodlands of the foothills. Physiographic deterioration of the basin's drainage system attendant to cultural erosion is most evident in the silt-clogged channels, enlarged sandy and muddy washes, cut stream banks, and the rapid extension of gully networks in Five Mile Creek, Muddy Creek, Badwater Creek, Muskrat Creek, and Beaver Creek. In the case of Five Mile Creek, waste irrigation water is causing most of the watershed breakdown. All of this is a rapidly progressive deterioration as the deepening or broadening stream channels and extending gully systems rush more and more water and silt at a steadily increasing rate.

Although every stream performs its part in sediment transportation and deposition, Five Mile Creek, Badwater Creek, and Muskrat Creek, on the basis of geologic evidence, appear to contribute most of the silt from the basin to the main river which is believed to carry the heaviest silt load of any major tributary of the Missouri system. The load received from Shoshone Basin is estimated by the War Department, Corps of Engineers, to average about 4,404 acre feet per year on the basis of studies carried on at Thermopolis from 1938 to 1944. There is no regularity from year to year in the amount of silt, the estimates varying from 1,800 acre feet to 7,000 acre feet.

Silt damage below Thermopolis is estimated by local interests at about $50,000 annually, exclusive of the detrimental silting of the irrigated soils. Boysen Reservoir, at the upper end of the Wind River Canyon, completed in 1910 with an original estimated capacity of 23,000 acre feet to produce hydro-electric power, was practically silted full by 1923. 10/ In the projected $8,202,000 (1940 prices) new multiple-purpose Boysen Reservoir, 260,000 acre feet of capacity will be provided for silt storage out of its total capacity of 820,000 acre feet. Assuming that the entire average suspended load of the river would be deposited in the reservoir and that silt compaction will not be appreciable, the dead storage capacity would be filled in about 60 years. However, experience with other reservoirs indicates that the bulk of the sedimentation accumulates in the upper portion of the reservoirs and, consequently, replaces usable water storage rather than dead storage in the lower part of the reservoir at the dam. It is the big floods like that of 1923, however, which will produce many times more effect on the silting of the reservoir than several years of regular run-off. Clarification of the Bighorn River will result in benefits to irrigation and municipal water works and added scenic, recreational and wildlife values.

CLIMATE

Climate restricts agricultural land use almost entirely to irrigation farming and livestock enterprises. It is of a continental, semi-arid, temperate type except in the encircling mountains where additional orographic precipitation provides a dry sub-humid to probably a humid climate at highest elevations. It is characterized by sparse precipitation of variable distribution and occurrence, comparatively long cold winters and short hot summers, a large proportion of possible sunshine, low humidity and high rate

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10/ Op. cit., Silting of reservoirs, pp. 93-100.

of evaporation, and quite frequent but not strong winds in every month of the year. Summarized data from the Weather Bureau Station at Lander are given in Table 1.

Precipitation.

Mean annual precipitation in the whole northern portion of the basin floor is less than ten inches. Annual precipitation averages 8.86 inches at Dubois 11/ 9.20 inches at Diversion Dam, 8.86 inches at Pavillion, and 9.47 inches at Riverton. At Shoshoni, which is claimed to be one of the driest points in Wyoming, annual precipitation averaged only 7.62 inches from 1931 to 1941, the period of record. South of a northwest-southeast line following the Wind River, precipitation increases as elevation helps to relieve the atmosphere of moisture. Annual precipitation averages 10.41 inches at Fort Washakie, 12.63 inches at Lander, and 18.02 inches at Middle Fork.. Precipitation also increases with elevation on the Shoshone, Owl Creek, Bridger, Bighorn Mountain slopes on the north side of the basin.

During the 54 years of record at Lander, there were 34 years with above average precipitation and 20 years below. The lowest yearly precipitation recorded was 7.25 inches in 1902, the highest 21.56 inches in 1923. In twelve of the twenty subnormal years rainfall totalled less than 11 inches, six years less than 10 inches, four years less than 9 inches, and two years less than 8 inches. All years have been dry sub-humid or drier with arid conditions prevalent in at least six years since 1900. The significant point is not that the supply of moisture is normally low in this area, but that minor fluctuations are sufficient to upset the balance in the forage supply and grazing demand which often results in depletion and subsequent deterioration of the vegetative and soil resources.

Distribution of annual precipitation from month to month is a very important factor in the production of range forage and irrigated and non-irrigated crops. Normally, most of the precipitation falls during the spring and summer. Typical of the Great Plains type of precipitation regimen, an average of about seventy per cent of the yearly precipitation occurs from April through September in the northern and central portions of the basin and a significantly smaller proportion at Lander and at Middle Fork in the Wind River foothills. Months of highest precipitation are April and May, the driest months from November through February when moisture usually comes as light snow. Surrounding mountains usually receive an abundant deposit of snow, chiefly in March and April, which usually furnishes an ample supply of water for irrigation through the early summer. Average annual depth of snow in April on the snow measurement course on Roaring Fork, elevation 10,300 feet, is about 54 inches (1932 - 1939, inclusive). Heavy, wet, spring snows, especially, are helpful in providing the necessary moisture for starting the growth of range forage. Snowstorms that come as blizzards and last for several days have resulted in serious losses to sheepmen.

11/ Weather data have been recorded for 38 years at Dubois, 26 years at Diversion Dam, 27 years at Pavillion, 30 years at Riverton, 39 years at Fort Washakie (near), 54 years at Lander, and 27 years at Middle Fork.

TABLE I
NORMAL AND EXTREME MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION
LANDER, WYOMING, 1892 - 1945
(Elevation - 5,351 feet)

	Temperature (53 year record)			Precipitation (53 year record)					
Month	Mean	Absolute maximum	Absolute minimum	Mean	Greatest on record	Least on record	Greatest in any 24 hrs.	Average days with 0.01 in. or more	Average snowfall
December	20.4	62	-40	0.68	2.06	T	0.98	4	7.5
January	18.3	64	-39	0.56	2.06	0.00	1.92	4	3.9
February	22.5	64	-35	0.63	2.32	T	0.81	5	8.3
Winter	20.6	64	-40	1.87			1.92	13	19.7
March	32.4	72	-24	1.19	3.56	0.13	1.90	7	11.7
April	42.4	82	- 7	2.06	7.19	0.10	3.45	8	13.9
May	51.3	88	13	2.26	6.06	0.30	3.66	9	4.3
Spring	42.0	88	-24	5.51			3.66	24	29.9
June	60.5	97	26	1.15	3.75	0.02	2.10	6	0.5
July	67.4	100	32	0.69	3.00	T	1.93	6	0.0
August	65.5	96	23	0.53	4.35	T	1.70	6	0.0
Summer	64.5	100	23	2.37			2.10	18	0.5
September	55.7	91	7	0.92	5.64	T	3.31	5	1.9
October	43.5	83	14	1.36	4.64	0.01	2.04	6	8.2
November	30.3	72	-31	0.60	2.55	0.00	1.60	4	6.9
Fall	43.2	91	-31	2.88			3.31	15	17.0
Year	42.6	100	-40	12.63	21.56	7.25	3.66	70	67.1

Source: U. S. Weather Bureau records, Cheyenne, Wyoming

T - Trace

In all seasons, except summer, the region receives its precipitation from invasions of Polar Pacific air masses. In summer, precipitation mainly originates from the northward moving Tropical Gulf air masses as convective showers or frontal storms, but as the prevailing wind is westerly high evaporation prevails in this season. Distribution of summer rainfall is erratic, some localities being completely missed by showers for long periods. Beating localized rains which produce excessive run-offs of great eroding power on fine soils occur quite often, but less frequently than on the Great Plains. Lander shows only twelve excessive rains during its period of record.

Temperature.

With rapid insolation and radiation of a dry upland climate and the sheltering high mountains surrounding it, the basin usually has decidedly warm, often hot, days but cool nights in summer. The fall is long and generally moderate which makes for favorable harvest weather. Though winters are generally rigorous, they are not excessively so, and, owing to the low humidity, the temperature seldom becomes very disagreeable. Spring is generally cool.

Average annual temperature at Diversion Dam is 43.8°, at Pavillion 44.7°, at Riverton 42.5°, at Fort Washakie 43.0°, at Lander 42.5°, and at Middle Fork 43.7°. At Lander the average monthly minimum is 4.8° in January and the average monthly maximum 83.5° in July. Highest temperature recorded is 102°, lowest -40°. In higher precipitation periods, the temperature tends to be lower than in drier years and vice versa. Mountain areas, of course, possess prevailingly cooler temperaturs.

Growing Season

Length of growing season also varies with elevation. Riverton, which is at 4,954 feet in the lower part of the basin, averages a 128-day growing season. Dubois at 6,917 feet elevation in upper Wind River sub-basin has about 70 days. It is much shorter at higher elevations. Length of growing season averages 127 days for the 54 years of record at Lander at 5,351 feet. The longest growing season reached 177 days at Lander, the shortest but 70 days. Latest killing frost ever recorded occurred on June 20th, the earliest on August 23rd. Occasional late spring or early fall frosts cause some crop damages.

Evaporation

Effectiveness of annual precipitation for crop and forage production is influenced significantly by the amount of evaporation and transpiration. Although evaporation and transpiration data for Shoshone Basin are not available, it is known that except in the mountainous areas the mean annual precipitation is normally less than the demands of evaporation and transpiration. This is evident from the average seasonal evaporation (April to September) of 34.86 inches from an open water surface recorded at Sheridan about 142 miles north of Riverton for a 19-year period.

Winds

West, northwest, or southwest winds prevail in all of the basin. Average wind velocity is 5.6 miles per hour at Lander which evinces the sheltering effect of the mountains. Highest average monthly wind velocities occur during the spring months, March through May. Wind velocities for short periods are frequently high; velocities of 40 or more miles an hour are not unusual. Winds of high velocity occur most often in spring and early summer. During the last nine years, wind velocities of 20 miles an hour or more for periods of 5 minutes or more were recorded on an average of 23 days in the period April to June. Such winds, especially if sustained for any length of time, are soil movers. It is probable that most soil blowing occurs during 2 to 4 days in the average year, mainly in spring and winter months. The more elevated areas experience heavier winds.

Sustained periods of hot, dry, desiccating winds are not uncommon in summer. In winter chinook winds frequently occur, bringing an abrupt rise in temperature of many degrees in a short period of time. Often snow is melted rapidly as a chinook moves into the basin, the excessive run-off and ice jams sometimes causing minor flood conditions.

VEGETATION

Native vegetation of the Shoshone Basin ranges from perannial semi-desert types in the lower elevations to alpine meadows in the Wind River Mountains. The better grazing lands are in the upper portions of the watersheds in or near the foothills and in the park-like areas in the mountains. The areas involving lands under jurisdiction of the Bureau of Land Management generally occupy the lower and intermediate elevations. These areas support a very important part of the livestock enterprises in the basin.

Vegetation of the basin floor is generally of a sagebrush type, with the shortgrasses and mid-grass type being interspersed. Of the sages, the common or big sagebrush (Artemisia tridentata) is the most prevalent as it grows on almost all soils not highly impregnated with "alkali" salts. The grasses which include thick spike wheat-grass (Agropyron daaystachyum), western wheat-grass (Agropyron smithii), Indian rice-grass (Oryzopsis hymenoides), giant rye-grass (Elymus condensatus), grama grass (Bouteloua gracilis), needle grass (Stipa comata), and many others interspersed among the shrubs generally provide about two-thirds of the forage. On the whole, this type was greatly misused in the past and is in only fair condition, and, although considerable improvement has taken place in recent years, additional range management measures are necessary to return it to optimum carrying capacity.

On the lowest, driest, and more alkaline soils of the basin, salt bushes prevail. Mat o Nuttall's salt bush (Artiplex muttallii), Nelson's salt bush (Artiplex pabularis), and allied species usually occur on soils from which the run-off is large and accordingly most deficient in moisture for plant growth. The total amount of growth produced is meager and the small, widely spaced, ash-colored mats blend with the desert soils and give a barren appearance. On soils of less extreme moisture conditions shadscale (Artiplex confertifolia) prevails. Greasewood (Sarcobatus vermiculatus) abounds on strongly alkaline soils where ground water rises to within

several feet of the surface as around Ocean Lake and the low flats immediately bordering many of the streams. Nutritious winterfat (Eurotia lanata) occupies land almost as heavy as that covered by shadscale but which is less alkaline. Bud sage (Artemisia spinescens) occupies rather limited areas but is highly valued by sheepmen for spring forage.

Vegetation in the mountain foothills includes principally bunch grasses such as June grass (Koeleria cristata), bluegrass (Poa pratensis, Poa buckleyana), wheat grass (Agropyron spicatum), three-awn grass (Aristida longiseta), and wire grass (Juncas balticus); sedges, principally the common sedge (Carex filifolia) and such shrubs as the common sagebrush, squaw brush (Rhus tribolata), mountain mahogany (Corcecarpus montanus), wild rose bushes (Rosa ap.), and buck brush (Symphoricarpos sp.) to which may be added many weeds and other flowering plants. Juniperus scopulorum and Pinus flexilis occur on the rocky ridges. Juniper dominated forage type is characterized by a sparse undercover, mostly sagebrush and grasses, and a low grazing capacity.

Much of the intermediate area which lies between the grasses, sedges, and brush of the foothills and the grasses and sedges of alpine meadows above the timberline on the high peaks and ranges is covered with mountain brush or with forests of spruce (Picea engelmanni), Douglas fir (Pseudotsuga taxifolia), lodge-pole pine (Pinus contorta), limber pine (Pinus flexilis), western yellow pine (Pinus ponderosa), and aspen (Populus tremuloides) with grasses, shrubs and weeds occupying the understory open spaces and parks.

Alpine vegetation of the upper mountain valleys and the high slopes and ridges above timberline consists chiefly of brome grasses (Bromus sp.), several fescues (Festuca sp.), rye grass (Elymus glaucus), mountain timothy (Phleum alpinum), pine grass (Calamogrostis sp.), rock sedge (Carex rupestris), and a great variety of broadleaved flowering plants attractive to tourists.

Grazing land types were mapped in northwest and southwest Wyoming by the U. S. Geological Survey, Department of the Interior, in connection with its Land Classification Study of the Northern Great Plains. Maps showing grazing land types in Shoshone Basin are therefore available from this source at a scale of 1:500,000.

Vegetative Deterioration

The physiography of the Shoshone Basin and its climate are both primary factors affecting land use and land problems, but the prevalence of swift run-off, localized watershed impairment, and excessive silting of the Bighorn River are attributable mainly to the widespread deterioration and, in some places, outright destruction of the native vegetation during the past sixty years. Although on most range lands the thin vegetative cover is gradually improving and is generally now in fair condition as a result of widely applied grazing regulations and the prevalence of above normal rainfall in recent years, in certain localities, notably in Badwater watershed, forage still remains generally poor in vigor and in some places virtually exterminated due to overstocking, unseasonal use, and excessive sheep trailing. In the vicinity of Lysite, the principal shipping point, the forage, as well as the soil resource, is severely depleted and continues to deteriorate with excessive trailing and use by livestock. Valuable grasses

formerly occupying much of the range have been partly replaced by economically inferior or worthless grasses, halfshrubs, and annual weeds.

Washakie National Forest

Timber resources are great as most of the national forest area is well timbered, especially in its middle and lower elevations where lodgepole pine predominates. The greater amount of mature timber is to be found in the northern part of the forest, since the southern portion suffered many fires before the area was made part of the national forest. It is estimated that Washakie National Forest contains approximately 1,614,000,000 board feed of timber, of which about 64 per cent is lodgepole pine. 12/ Railroad ties are, at present, the most valuable product of the forest, although a great deal of lumber has been produced mostly as a by-product of tie manufacturing. The forest furnishes summer grazing for approximately 10,000 head of cattle and horses annually, and 40,000 sheep for a period of from three to four months.

SOILS

The sedimentary sandstones, clays, and shales comprising so much of the basin area, in the process of weathering and soil genesis, commonly produced fine soils. Heavier textured and tighter clay soils are more prevalent than the lighter textured and permeable sandy soils. Soil development has proceeded further on sandstones than upon shales and other heavy parent materials. Most mature soils occur upon undisturbed upland levels. Lime has generally been leached downward 9 to 12 inches in soils near the mountains and from 3 to 6 inches in comparable soils 20 to 25 miles away from the mountains. Loam soils on level benches and terraces or on alluvial fans and valley fill generally rate as the best irrigable soils. On the whole, the extensive upland soils are capable of producing a good crop of livestock forage. On the rough broken land and in badland areas there is usually very little soil on which much forage can grow.

Surveyed Soils

About 700 square miles, or 448,000 acres, in the central portion of the basin have been covered by soil surveys. 13/ The survey inclues both irrigated lands and lands outside of existing irrigation projects in the ceded and unceded portions of the Wind River Indian Reservation along the Wind, Little Wind, and Popo Agie Rivers and Five Mile Creek (Figure 2). Descriptions of the various soil series differentiated by the survey are abstracted from the survey report and presented in appendix I.

Unsurveyed Soils

Characterization and mapping of soils outside of the surveyed areas

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12/ Forests of Wyoming, Wyoming State Planning Commission, 1938.

13/ Dunnewald, T. J., Williams, Orel, and Stevens, Delvin, Soil survey of Lander - Riverton area, Fremont County, Wyoming: Wyoming Soil Survey (manuscript in files Dept. of Agronomy, Univ. of Wyoming), 1932.

is more general by soil groupings and is based on an unpublished map, Wyoming Soil Groups, and soil descriptions prepared by the Department of Agronomy; University of Wyoming. Correlation of the data presented in this map and the detailed soil maps and the soil descriptions which accompany each enable the following generalized accounts of the unsurveyed areas which are commonly used for grazing.

Brown Bench and Bottom Soils - This group occupies the bottom lands and more level terraces along Bighorn River and its principal tributaries - Badwater Creek (Bridger Creek), Poison Creek (Canyon Creek), Muskrat Creek (Conant Creek), Alkali Creek, Popo Agie River (Beaver Creek, Little Popo Agie River, and Little Wind River affluents), Wind River (North Fork and Bull Lake member streams), Muddy Creek, upper Five Mile Creek, and Dry Cottonwood Creek; the alluvial bench lands; and alluvial fans at the base of the mountains. The first bottom land soils include the dark brown Laurel and blackish Harlem or similar soils and are subject to occasional floods and high water table (See appendix I for description of Laurel and Harlem soils). The level terrace and benchland soils generally possess relatively sandy and brown-colored topsoil and a more compact brownish loam to clay loam subsoil. Lime accumulation of varying thickness prevails at 8 to 24 inches below the surface. Gravelly or sandy substratum often occurs which assures good drainage. Wind River Series, or soils similar to it, occupy the higher alluvial fan and terrace lands and the grayer, less developed Ethete Series, or soils comparable to it, occupy the lower alluvial terraces generally of more recent origin (See appendix I for description of Wind River and Ethete Series). These soils, productive if supplementary water is applied, are the mainstay of the basin's agriculture. Further extension of irrigation on this group of soils depends mainly upon future development of water storage facilities.

Shallow and Stony Loams - This group prevails on the more rolling and shallow basin and valley lands and are best adapted to grazing because of their uneven surface and shallow characteristics. It is the most extensive soils group in the basin and supports chiefly short grass and sage types of vegetation. Soil types of the Arapahoe Series, or soils similar to them, prevail in the rolling, sandy shale rock areas, while soil types of the more mature Saddle Series, or soils similar to them, obtain on the more undulating sandstone sections (See appendix I for descriptions of Arapahoe and Saddle Series). Soils developed from heavy clay shales are apt to contain more soluble alkali salts and evince poor drainage, salt accumulations, and stunted plant growth. The character, value, and grazing capacity of the vegetative cover varies from year to year with the variability of precipitation occurrence.

Pierre Alkali Clays and Loams - This group includes all of the larger areas of heavy alkaline soils developed upon marine shales (clay loam and clay types of Arapahoe Series) or produced by the accumulation of salts from adjacent shales and all lands bearing alkali tolerant vegetation such as greasewood, shadscale, salt bush, and salt grasses. These soils produce a high protein forage, especially during the short period of favorable moisture supply in the spring. These soils are limited to grazing use. Principal occurrence is in the interstream area between Muddy Creek and Five Mile Creek and southward east of Pavillion.

Mountain Soils - This group includes all areas within the Washakie

National Forest, all wooded foothill land, and all stony and rough areas covered with mountain brush and sub-alpine vegetation. Timbered mountain soils are generally grayish-brown loams which occupy the more rolling areas. Grassland mountain soils generally are darker in color and less stony and occupy the valleys, basins, and smoother undulating ridges. Both timber and grassland soils test neutral to acid in reaction. Soil types of the reddish Chugwater Series derived from the sandstone and limestone rocks of the Chugwater formation occur on the flanks of the Wind River and Owl Creek-Bridger Ranges. (See appendix I for description of Chugwater Series). Summer grazing by sheep and cattle, timber production, and recreation constitute the principal uses of areas supporting these soils.

Soil Erosion and Siltation

Silt that muddies the Bighorn River is the eroding fertile topsoil swept from the uplands as well as the unweathered clays and sands sloughed and scoured from along the valley bottoms and the subsoil flushed from the ever expanding and deepening gully systems. Fortunately, except in localized areas where lands have been most misused, soil erosion is only slight (25% of topsoil or less removed) to moderate (25-75% of topsoil removed) in the basin. Principal conditions which foster erosion, particularly in areas of land abuse, are high erodibility of disturbed soils, intensity of occasional spring and summer rainstorms, rapid melting of deep snows in elevated portions, comparatively sparse vegetative cover over much of the area, and the generally rolling, rough, or mountainous topography of the basin. Factors which reduce vulnerability of soils to erosion are the low rainfall, small proportion of cultivated land, the protecting vegetative cover which in large part has never been disturbed by the plow, and the wind resistant surface mulch and crust on virgin soils.

On the whole, water erosion is more injurious and widespread than wind erosion. Water erosion occurs mainly in the canyons and gullies of the foothills where run-off from thundershowers concentrate, in the vegetation depleted areas of the basin floor, and along stock trails. Wind erosion occurs in moderate degree on tilled irrigated soils of a sandy to sandy loam texture which are left loose and bare all winter, in the badland areas, and on depleted ranges and stock driveways where the vegetative cover is insufficient to hold soils intact. Soil blowing and small dunes are found associated with some of the larger intermittent stream bottoms.

On lands under the custody of the Bureau of Land Management, the Badwater Creek watershed with its widespread forage depletion evinces the worst wind and water erosion. Blowing and sheet and gully erosion is most notable along the southern uplands of this watershed; gullying occurs in rougher areas of upper Dry Creek tributary, gullying and some sheet and wind erosion in Alkali Creek, and bank cutting along the Badwater itself. In Poison Creek drainage, many intermittent tributaries and the main channel contribute moderate amounts of silt if precipitation is heavy; also several sand dune areas continue to be active. This drainage is more stabilized, however, than either the Badwater or Muskrat drainages. In upper Muskrat Creek, occasional gullies occur and intermittent streams during flood periods carry considerable silt. Severe gully erosion at the heads of Beaver and Hall Creeks is slowly healing as a result of management and reduction of livestock in the area. Erosion conditions are considered light in upper Wind River watershed about Dubois.

On other lands, most serious erosion has occured along Five Mile Creek where the channel has been deepened and the sides sloughed mainly by waste irrigation water. Lower Wind River sub-basin and Little Wind River watershed were designated as critical erosion areas by the U. S. Department of Agriculture erosion survey in 1935.

If erosion conditions are gauged by deducting the silt losses evenly over the entire basin surface, soil and parent material losses are going on at the rate of more than one acre-foot each year for every two square miles. Erosion on such a scale is symptomatic of disrupted natural balances and land breakdown. It is true that there is geological erosion and that heavy raw shale areas undoubtedly muddied the streams even as virgin land, but much of the excessive run-off and silt can be traced back to misused land surfaces. The great engineering control and reclamation program projected for the main river must be matched by a complete and integrated program of upstream land improvement and management to cure the ills of the back country grasslands.

ECONOMIC AND CULTURAL DEVELOPMENT

Water, grass, timber and mineral resources of the Shoshone Basin early attracted cattle men, farmers, and prospectors. The first few families settled in the Lander area in 1867. The Indians had signed a treaty establishing the Shoshone or Wind River Reservation in that year. Also in that year, a well-armed group succeeded in working the rich Carissa Lode which brought on the gold rush to South Pass in 1868. In 1869, Ft. Augur, later renamed Camp Brown, was established. Irrigation works were constructed along the Popo Agie River in the vicinity of Lander inthe late sixties. After 1870, in the era of the open range, thousands of head of cattle were trailed northward from Texas to establish great cattle ranches. The Arapahoes were temporarily quartered at the Shoshone Reservation in 1877, and have remained there since. The military post was moved onto the reservation and renamed Fort Washakie in 1878.

Lander was laid out and oil first discovered in 1883. Fremont County was orgainzed in 1884 and by this time it was predominantly sheep country. The servere drought of the summer of 1886 followed by one of the hardest winters of the teritory marked the beginning of the end of the large cattle companies. By treaty in 1905 the original Indian reservation was reduced by ceding to the Government 1,346,320 acres of land north of Wind River. With the money received from the sale of these lands, the Government undertook more extensive irrigation developments within the diminished reservation. About 78,000 acres of Indian lands thus came under constructed works but, of the 21,500 acres now irrigated, Indians use only 7,000 acres and white purchasers and renters the rest of it. On the ceded lands, work on a privately-owned irrigation system began at once but only settlers with fortitude, endurance, patience and perseverance eventually made progress. About 18,000 acres in the bend of Wind and Bighorn Rivers gradually were irrigated from privately owned LeClair and Wyoming No. 2 ditches.

The Chicago and Northwestern Railroad arrived in 1906. By this time sheep numbers had increased greatly and unregulated grazing accompanied by keen competition for forage resulted in severe range misuse. In addition, World War I incurred a large increase in cattle. A little dry farming was attempted from time to time from 1906 to 1920 under conditions of high

rainfall and high prices. Great expansion of irrigation took place between 1900 and 1920. The first 20 farming units of the Riverton Project were opened by the Bureau of Reclamation in 1926. Livestock populations have increased as the irrigated acreage has expanded.

The area is fairly well supplied with transportation facilities. Oiled roads connect Shoshoni, Riverton, Lander, Fort Washakie, and Pavillion. Federal highways 20, 320, and 287 provide outlets from the main parts of the basin to Billings, Montana, Casper and Rawlins, Wyoming, and cities of the Pacific Northwest. Comparatively few of the county roads are graded or gravelled. The basin is serviced by the Chicago, Burlington and Quincy Railroad which traverses the northeastern part enroute from Casper through the Bighorn River canyon to Billings. Chicago and Northwestern Railroad serves the area from Bonneville to Lander. Omaha, Nebraska, one of the principal markets for livestock, is about 765 miles from Riverton.

Public service utilities, commercial activities, and social services have generally kept pace with agricultural development. Two power utilities serve the region. Natural gas is piped into Lander and Riverton. Telephones are reported to be in common use and mail routes reach nearly all sections. The area is adequately supplied with warehouses, a grain elevator, and other marketing and shipping facilities. Public schools are well developed throughout the area and hospitals and other social facilities are available in the larger communities.

Riverton is the business center of the Wind River sub-basin. Lander serves as county seat and commercial center of Popo Agie Valley. Dubois functions as a trading center in the northwest portion of the basin, and as a dude ranch and hunting base. Shoshoni serves as a community center for livestock operators in the northeastern portion of the basin. Hudson is an agricultural trading and coal mining town. Fort Washakie serves as Shoshone Indian Reservation headquarters.

POPULATION

The area in general is sparsely settled. Population of the Shoshone Basin, based on the U. S. Census of 1940, is approximately 16,000. An increase of about 5,600 people took place in the decade between 1930 and 1940, many of whom were drought refugees who left dry land areas in Colorado, Wyoming, Kansas and Nebraska. The population is nearly half rural-farm, about one-third urban, and the remainder rural non-farm. The Indian population of about 2,225 includes Shoshones and Arapahoes, about equally divided on the Shoshone Indian Reservation. The Indian population increased 31% between 1930 and 1940. Between two and three hundred Spanish Americans reside in the area, being engaged largely in sugar beet farming or sheepherding. About 2,300 persons, 14 years old and over, are engaged in agriculture. Lander is the largest town with a population in 1940 of 2,594. Riverton, with 2,540 people, ranks next. Of the incorporated communities under 2,500, Dubois is largest with 412 inhabitants and Shoshoni next with 226 people.

Division of the authorized expansion of 57,500 acres in the Riverton Project into farm units of 80 acres would result in a total of about 720 new farms. On the basis of the belief that new farms of that size should support an average of five persons, a total increase of about 3,600 people may eventually take place in the rural-farm population.

At least an equal increase in urban population may be expected from such development.

LAND OWNERSHIP AND CONTROL

Land ownership and control strongly influence land management and the improvements which can be made in management. Of the approximately 5,120,000 acres in the basin, about 28.9 per cent lies within Wyoming Grazing District No. 2. 44.3 per cent within the diminished and ceded portions of Wind River Indian Reservation, 16.2 per cent within Washakie National Forest, 4.3 per cent within Riverton Irrigation Project, and 5.8 per cent in four separate nuclei of public domain (northwest Natrona County, southeast Hot Springs County, central Popo Agie watershed, and upper Wind River watershed) outside of established public land program areas. State lands and private lands on which limited or no conservation controls can be directly exercised by the Federal government are interspersed within the managed and unmanaged areas and total 208,978 acres and about 500,000 acres, respectively. Incorporated city areas occupy about 4,000 acres.

The gross area of Indian lands comprised 2,268,073 acres, of which 185,791 acres have been alienated to white ownership. Some leases of tribal lands for grazing purposes are issued to white settlers. About 62 per cent of the approximately 1,477,280 acres in the grazing district consists of Federal land, the rest state land and private land. Of the approximate 220,000 acres within the boundaries of the Riverton Irrigation Project, about 62,000 acres have been patented. Within the boundaries of the Washakie National Forest lie approximately 830,700 acres of Federal land and a few small tracts of state and private lands totalling about 1,300 acres.

A total of about 1,343,935 acres are under the custody of the Bureau of Land Management. This includes approximately 1,044,960 acres of grazing district lands and 298,975 acres of public domain in various status categories. Specifically, there are 193,096 acres of public domain under grazing lease, 28,729 acres in stock driveway withdrawals, 160 acres in public water reserves, 1,440 acres under coal permit, 2,760 acres under oil and gas lease, 40 acres under application to purchase, 63,890 acres vacant, 1,760 acres in petroleum reserve withdrawal, and 7,100 acres in phosphate reserve withdrawal (Table 2). The War Department Target Reserve withdrawal comprises 1,400 acres.

The land use and land administration problem arises in the Natrona, Hot Springs, Popo Agie River, and upper Wind River areas referred to above from the checkered pattern of Federal, state, and private ownership. A good deal of public range lands and to a lesser extent private range lands exist in small tracts that cannot be used as independent range units. Isolated pieces of land, usually unfenced, are rented or remain open to trespass and excessive use. A possible solution in the areas adjacent to the grazing district in Natrona and Hot Springs Counties is the inclusion of those areas in the grazing district for administration and range management. Study should be made of land ownership and administration in the Dubois and Popo Agie watershed areas to establish a future land administration or disposition program for the public land in those areas.

Table 2. Status of Public Domain Lands in the Shoshone Basin.

Land Status	Fremont County Acres	Natrona County Acres	Hot Springs County Acres	Total Acres
Within Grazing Districts				
Unreserved	801,980			801,980
Stock Driveway Withdrawal	104,900			104,900
Public Water Reserve	960			960
Power Site Withdrawal	1,090			1,090
Reclamation Withdrawal*	6,970			6,970
Sub Total	915,900			915,900
Outside Grazing Districts				
Unreserved, leased for grazing	58,750	131,426	2,920	193,096
Unreserved, unleased	60,070	420	3,400	63,890
Stockdriveway	1,480	27,249		28,729
Public Water Reserve	160			160
War Dept. Target Range	1,400			1,400
Petroleum Reserve	1,760			1,760
Coal Permit	1,440			1,440
Oil & Gas Lease	2,760			2,760
Phosphate Reserve	7,100			7,100
Sub Total	134,920	159,095	6,320	300, 335
Grand Total	1,050,820	159,095	6,320	1,216,235

* Part of the lands under Reclamation Withdrawal are also embraced under Power Site Withdrawal.

PRESENT AND FUTURE IRRIGATION

Irrigation projects in Shoshone Basin contain a total irrigable area of 210,800 acres, of which 110,900 acres were irrigated in 1940 (Table 3). The area under developed projects in each watershed is as follows:

Table 3 - Shoshone Basin - Irrigated and Potentially Irrigable Lands Under Existing Projects

Stream	Irrigated in 1940 (acres)	New Land Under Existing Works 1/ (acres)	Ultimate Area Under Existing Projects (acres)
Wind River	68,600	2/ 80,700	2/ 149,300
Little Wind River and tributaries	17,500	16,500	34,000
Popo Agie River, main stream	1,800	600	2,400
Little Popo Agie River	2,700	0	2,700
Middle Fork Popo Agie River	7,100	100	7,200
North Fork Popo Agie River	5,100	100	5,200
Baldwin Creek	1,400	0	1,400
Squaw Creek	900	0	900
Willow Creek	2,100	0	2,100
Beaver Creek	900	300	1,200
Badwater Creek	1,100	1,600	2,700
Bighorn River 3/	1,700	0	1,700
	110,900	99,900	210,800

1/ Includes minor areas of land previously irrigated.

2/ Includes 65,300 acres of irrigable land under the Riverton Project authorized for construction but for which distribution system has not been built.

3/ Above Thermopolis.

Source: Missouri River Basin Conservation, Control and Use of Water Resources; Sen. Doc. 191, 78th Congress, 2nd Sess.

The Riverton Project is the largest single project in the Shoshone Basin. The present system irrigates about 42,500 acres. Authorized extension of the Wyoming Canal to the north of Muddy Creek and completion of the Pilot Canal lateral system will add 57,500 acres, making the ultimate area 100,000 acres. Office of Indian Affairs projects, when fully developed will provide about one-fourth the aggregate irrigated area, roughly equalling that of the private enterprises. Proposed additional irrigation projects in the Missouri Basin program include the Fremont, Little Wind River, Popo Agie, Hudson Bench, Shoshone, and Badwater Units which would provide 23,900 new irrigated acres and supplemental water supplies to 51,400 acres.

Boysen Reservoir, when completed in the Wind River canyon, will submerge at high water mark all lands below the 4,740 feet contour. While most of the flooded area will be ceded Indian lands, approximately 2,000 acres of it comprises public lands within the grazing district. A first form withdrawal of 6,974 acres of public lands has been made by the Bureau of Reclamation on the east side of the projected reservoir in the grazing district. Base properties which will be flooded or otherwise lost and the reduction in public grazing area will necessitate some local adjustments in the grazing economy.

LAND USE

Crop Production

Virtually all crops in the Shoshone Basin are grown under irrigation and most of them are closely related to the livestock industry. 14/ Of the approximate harvested acreage in 1939 of 89,800 acres, hay crops constituted about 56 per cent, small grains 24 per cent, sugar beet, dry bean, corn, and potato row crops 12 per cent, and vegetables, berries, melons, and other minor crops the remaining 8 per cent.

Alfalfa is the principal hay, accounting for about two-thirds of the hay acreage in 1939. Oats, little of which is shipped out, comprised approximately 52 per cent of the harvested acreage of small grains in 1939; wheat, chiefly spring wheat, 25 per cent; and barley nearly 23 per cent. Rye is seldom grown except for fall pasture or cover crop. Finishing of cattle and hogs for market is done more with small grains than corn. The sugar beet acreage, lying chiefly within 10 to 15 miles of the railroad, increased from 763 acres in 1924 to 3,668 harvested acres in 1939. Of late years, both sugar beets and dry beans have gained rapidly in favor as cash crops as their by-products are valuable as stock feed.

Three types of farming prevail in the Lander-Fort Washakie-Riverton irrigated crop-producing areas, namely, stock farms, general farms, and crop specialty farms. 15/ It is believed that irrigated lands of Riverton Project extensions will produce crops similar to those now raised on the Riverton Project which consist mainly of alfalfa hay and other forage crops, cereal grains, beans, potatoes, and sugar beets.16/

Livestock Production

It is estimated that 90 per cent of all the land in the area is used for grazing purposes, either as winter, spring, fall, or summer pasture or range. Both cattle and sheep are grazed on the open range lands. The forested and upper areas are used primarily as summer range; intermediate areas as spring, fall, and winter range, with some use in summer by local ranches; and the lower areas, particularly in the vicinity of Shoshoni, principally as winter range, mainly by sheep.

In April 1940, approximately 196,800 sheep and 37,300 beef cattle were owned in the basin, which, including young animals produced during the year, were equivalent to 83,730 animal units (Table 4). Other livestock, including poultry, constituted 20,500 animal units. The latter comprises essentially non-range livestock, although horses and dairy cattle, especially dairy calves obtain some feed from the range.

14/ Of the cropland harvested in 1939 in Fremont County, which includes all of the Shoshone Basin except a discontinuous, irregular, narrow and mountainous fringe in Hot Springs County, and a relatively small portion in northeastern Natrona County, 99.3 per cent comprised irrigated land.

15/ Hunter, Byron and Pearson, H. W., Types of farming areas in Wyoming: U. of Wyoming Agr. Exp. St. Bull. 228, pp. 168, 1938.

16/ U. S. Dept. of the Interior, Bur. of Reclamation, Riverton Project extensions, Wyoming-summarized report, p. 2, rev. May 1946.

Table 4. Estimated Animal Units of Farm and Range Livestock in Shoshone Basin - April 1, 1940 [1].

Kind	Number	Animal Units [2]
Sheep (over 6 mo. of age)	196,800	39,360
Lambs raised	[3] 147,600	[4] 4,970
Cattle (over 3 mo. of age exclusive of milking dairy cows)	37,300	37,300
Calves raised	[3] 12,400	[4] 2,100
Dairy cows in milk	4,500	6,000
Calves raised	[3] 1,575	[4] 270
Horses and mules (over 3 mo. of age)	11,000	11,000
Hogs (over 4 mo. of age)	5,000	800
Chickens (over 4 mo. of age)	64,800	650
Chickens raised	113,500	230
Turkeys (over 4 mo. of age)	5,000	1,330
Turkeys raised	22,200	220
TOTAL		104,230

[1] Based on number of animals enumerated in U. S. Census of 1940, except as otherwise noted.

[2] Calculated on the basis that beef cattle and horses and mules over 3 mo. of age are equivalent to one animal unit. Five sheep = one animal unit. Dairy cows = 1-1/3 animal units. Pigs = 1/6.3 animal units (excluding tankage). Chickens (mature) = 1/100 animal unit; young raised = 1/500 animal unit. Turkeys (mature) = 1/33 animal unit; young raised = 1/100 animal unit.

[3] Calculated from available statistical data.

[4] Estimated.

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It is likely, however, that not over 20 per cent of the feed of farm horses and 10 per cent of the feed of dairy cattle is derived from range land. It is estimated that strictly range beef cattle received about 25 per cent and range sheep 6 per cent of their total feed from farm crops and pasture. The requirement for all basin livestock is approximately 74,303 animal unit years or 891,636 animal unit months derived from range lands and 29,927 animal unit years or 359,124 animal unit months from farm land.

Forage Production

There are about as many livestock in the Shoshone Basin as can be supported under present conditions. No material sustained increase in the number of range animals can be expected owing to limitations of range carrying capacity. The development of irrigated pastures and other dry land pastures which would permit a greater portion of the yearlong use of pasture and crop land would relieve or shorten the period of use on range lands and, thereby, permit the grazing of a greater number of livestock. However, rather rough computations on the basis of incomplete data on carrying capacity of range lands indicate that range forage supplies do not quite equal range forage requirements. Farm lands, exclusive of farm pastures, are estimated to have produced grain, hay, and forage by-product crops in 1939, which, if all used for livestock forage, was equivalent in value to about 102,400 tons of alfalfa hay which is calculated to be equivalent to 25,600 animal units of forage. Although no reliable figures are available on forage supplies from irrigated (17,595 acres) and non-irrigated (about 5,000 acres) farm pastures, it is believed that the amount is about sufficient when added to other farm forage supplies to meet practically all of the present animal unit year requirements from farm lands even if allowance is made for the sale of the wheat and part of the barley grain crops.

Ranching Areas and Operations

Sheep, beef cattle, dairy cattle, swine, poultry, and horses figure in the livestock enterprises of the irrigated areas in the central portion of the basin. Range sheep and cattle are of primary importance, however, and most of them are grazed on the adjacent open range lands of the Shoshone Indian Reservation, Washakie National Forest, Wyoming Grazing District No. 2 or on non-district range lands. It is estimated that about one-fourth of the cows milked are of dual purpose breeding. Stock farms and ranches are easily the dominant type of farm. 17/

On grazing lands of Wyoming Grazing District No. 2, of Natrona County and Hot Springs County portions of the basin, and on ceded portions of the Indian reservation where only small and widely scattered irrigable tracts provide crop production opportunities, principally hay, sheep and beef cattle ranches, predominate. Ranches and stock farms on these lands average much larger in size and do a much greater volume of business than do the livestock enterprises of irrigated areas. 18/

17/ Op. cit., Hunter, Byron and Pearson, H. W., p. 169.

18/ Op. cit., Hunter, Bryon and Pearson, H. W., p. 94.

Operators of large sheep outfits generally keep their sheep on the range throughout the year, the mountainous district being used as summer range from about July 1 to the middle of September and the foothills in the late spring and early summer and in the fall until late November or early December and on the lower ranges in the basin during the winter. Very little feeding except during storms or other emergencies is done. Death losses resulting from drought and overstocking the range with consequent starvation; severe storms at shearing and lambing time, deep snows and blizzards during the winter and early spring, poisonous plants, predatory animals, and straying run comparatively high. Cattle and horse death losses within Wyoming Grazing District No. 2 from all causes was approximately 2.4 per cent in 1945 with poisonous plants and storms equally responsible for most of them. Sheep losses in 1945 totalled nearly 9.7 per cent with storms accounting for 6.7 per cent, predators 1.2 per cent, and poisonous plants about 1 per cent.

In the upper portion of Wind River sub-area where enough irrigated hay can be grown to supplement the spring and fall range forage and carry cattle through the winter, cattle ranching predominates, although sheep grazing is important. Most of the outfits which summer graze their sheep on the national forests in this portion of the basin have their headquarters within the grazing district. Beef cattle are generally summer grazed on the national forests or on tribal lands leased from the Office of Indian Affairs and spring and fall grazed in the mountain foothills on public domain and privately owned lands and on irrigated pastures and meadows of home ranches.

With the development of additional irrigated forage-producing land, the feeding and fattening of livestock for market should become an even more important industry. The increased feed producing capacity of the irrigated lands, however, should be balanced, as far as conservative range use permits, with increased available forage on open grazing lands. It is believed that range rehabilitation, combined with extension of scientific range management practices, will increase substantially the carrying capacity and improve the economic position of the livestock industry of the basin. The overgrazing in areas where land breakdown is occurring should be immediately dealt with. It is estimated that more than half of the livestock exported are shipped unfattened, mostly to Nebraska. Wool "in the grease" is shipped to Boston and other eastern markets.

INDUSTRIES

Farming and livestock raising are the principal industries in the basin, employing in 1940 nearly half of the working population. Industries other than those related to agriculture include oil and coal production, small scale lumbering, rail and truck transportation, construction, tourism, and service trades. By far the largest part of the population is supported directly or indirectly by agricultural production, processing, and marketing. There is a flour mill at Lander and a cooperative creamery at Riverton. Possibly further expansion of sugar beet and other crop specialties will induce the installation of a sugar mill and development of other processing industries. Sugar beets are shipped to Worland for refining at the present time.

Minerals

In 1940 nearly one hundred persons were gainfully employed in the mineral industries. Mineral production of the basin includes principally oil, natural gas, and coal. The fuel minerals are widely distributed, being produced in commercial quantities in the southern and western portions of the area.

Sub-bituminous coal seams occur in two large fields, one extending from northwest of Hudson to southeast of Poposia and the other northwest-southeast between Bargee and Pavillion. In 1945, the region produced 10,115 tons of coal from mines with an annual output of 1,000 tons or more at an average value of $3.43 a ton. A few of the mines in the vicinity of Hudson have supplied practically all of the local coal needs and there is no significant outside market.

Pilot Butte oil field which lies on both sides of the Wind River in the Shoshone Indian Reservation is one of the main oil producers, output reaching 260,000 barrels in 1945 19/ and 370,000 barrels in 1944. A three-inch pipeline 20 miles long delivers Pilot Butte oil to Riverton where it is shipped by rail to Casper for refining. The Lander Oil Field which occupies the structural fold flanking the Wind River Range on the northeast side includes Dallas Dome which is rated as a relatively important black oil producer, the Hudson field which has supplied fuel oil to the Chicago and Northwestern Railroad for many years, and Plunkett, Derby, and Sage Creek domes. Maverick Springs field, including Big Dome, Little Dome, and Circle Ridge Dome, produced 324,000 barrels 19/ of black oil in 1945. The oil is piped to the vicinity of Lysite and thence in the Elk Basin Field 12-inch line to Casper. The recently opened Steamboat Butte field produced most oil in 1945, the light and black crude petroleum totaling 1,017,000 barrels 19/. Winkleman oil field, opened in 1944, produced 117,781 barrels in that year. The Sinclair Wyoming Oil Company's Lysite anticline holdings in the northeastern part of the basin brought in a gasser in October 1946, but the well is being drilled deeper. Big Sand Draw has the largest market production of natural gas with an output of 5,094 million cubic feet in 1945. 19/ A pipe line has been built to Lander and Riverton and to Casper and Glenrock so that Big Sandy Draw can supply those towns with gas. Minor gas producers are Beaver Creek and Muskrat fields.

Up to the present time the basin has produced no copper, though ores of copper exist at several places in the Bridger and Bighorn Mountains. Some interest has been shown in recent years in the beds of rock phosphate which extend continuously for many miles in the Owl Creek and Wind River Mountains. Gypsum occurs in thick beds near Lander, but commercial production seems unlikely. An asbestos deposit is located on the southern border of the basin in T. 30 N., R. 96 W. Although the fiber is fine and flexible, the shortness of most of it and the small amount shown in the trenches indicate that successful commercial production is unlikely. 20/

19/ Preliminary production figures subject to revision by U. S. Bureau of Mines.

20/ Beckwith, R. H., Asbeston and chronite deposits of Wyoming, Geol. Survey of Wyoming Bull. No. 29, p. 822, 1939.

Alluvial deposits in Popo Agie Valley contain clays from which bricks are made at Lander. Mica, beryl, tungsten and tantalite deposits are found in the Bridger Mountains. Precious metals have been extracted in small quantities in Wind River Range.

Lumbering

About 75 persons are engaged in logging, forestry and woodworking in the basin. On the upper slopes of the Wind River watershed about Du Noir the surrounding stands of timber in the Washakie National Forest are cut annually on a sustained yield basis for tie logs. They are cut and treated at Du Noir and afterwards distributed for use along the Chicago and Northwestern Railroad.

Tourism

Recreation for tourists is provided by the wonderful scenic resources of the western part of the area, hundredsof miles of good fishing streams and more than one hundred lakes, all stocked with trout, the abundance and variety of big game, the wilderness areas of Washakie National Forest, and the large living glaciers in the Wind River Mountains. There are a great many "dude" ranches in the foothills of Wind River Range, especially in the vicinity of Dubois, from which scenic pack trips and hunting trips are provided. Shoshone Basin is also on main routes to Yellowstone Park, famous Jackson Hole, and Grant Teton National Park and provides accomodations for tourists enroute to those areas. Water sport and wildlife development at the projected Boysen Reservoir will no doubt add to the recreational attractions in the basin.

In the land classification and planning investigations in the Shoshoni Basin, the Bureau of Land Management will concentrate its work in two principal problem areas or sub areas; (1) the Badwater drainage and (2) the area between Lander and Shoshone and north of the Beaver Rim including the drainages of Poison Creek, Muskrat Creek, Beaver Creek, Twin Creek and Little Popo Agie Creek. (See figure No. 1) The detailed studies will include an inventory of the public land resources, an appraisal of the utility under the comprehensive resource development program, including their watershed significance and a determination of needed adjustments, improvements, or developments for full realization, utilization and perpetuation of the land resources.

RECOGNIZED LAND PROBLEMS

There are five principal land problems in the basin:

1. Prevention of soil and water losses.
   This is a result of a set of interacting physical processes--vegetative depletion, swift run-off, soil erosion, physiographic deterioration, and excessive sedimentation--which must be dealt with together, mainly on the uplands. Since erosion and siltation cannot be prevented in an absolute sense, and the normal rate of run-off and erosion is that which concurs with natural conditions of cover and use, the problem of control, except in localized areas, is largely a determination of where and how the range vegetation can

be utilized without disturbing the natural balance. In those localities where advanced watershed breakdown is occurring, however, it is necessary to make reparation for past errors by initiating a comprehensive range rehabilitation and maintenance program based on scientific soil and moisture conservation practices.

2. Provision for maximum watershed services.
Delivery of the maximum amount of usable water with a minimum of erosion and silting for irrigation use will contribute greatly to the economic development of the entire Bighorn Basin. In the long run, this will be largely attained by successfully coping with the first problem. The immediate concern is protecting the present and projected large public and private investment in irrigation systems and the Boysen Reservoir by reducing siltation.

3. Integration of irrigated crop land and range land uses.
This is most important since irrigated crop production will be increased 52 per cent by the authorized Riverton Project extensions and a 90 per cent increase is eventually contemplated in the Missouri Basin development program. The increased supplemental feed production which is expected to attend the expansion of irrigation should be accompanied by efforts to balance it as far as possible with increased cheap range forage which affords the basin's livestock industry its primary competitive advantage. Methods of increasing range forage supplies are restoring depleted range land to full productivity; providing access to unused or underused ranges; improving range management by correct livestock numbers; adequate control of seasonal movements; permanent allotment of public ranges; and attention to obtaining good animal distribution on the range; and by such conservation practices as reseeding, waterspreading and other moisture control, erosion and siltation retardation, watershed protection, and game control. Maladjustments in range land use inescapably reacts upon irrigated cropland use. What benefits the former benefits the other.

4. Reduction of range livestock hazards.
Sheep death losses in 1945, an average year, totalled nearly 9.7 per cent and cattle and horse death losses 2.4 per cent in Wyoming Grazing District No. 2. On unmanaged range they undoubtedly are higher. Under conservative grazing and good range conditions, with adequate supplemental feed for emergencies, sheep losses usually do not exceed 5 per cent and sometimes run lower. Animals in weakened condition from excessive stocking are most susceptible to storm, predators, and disease hazards. Mortality from poisonous plants in also invariably heaviest when livestock are undernourished and the forage supply is short.

5. Provision of efficient and economical public domain administration.
Range resources of the concentrated Federal public domain in northwestern Natrona County and southeastern Hot Springs County should be placed under grazing district administration for efficient and economical management. The proper policy for administering the public domain should be determined in the Dubois area of Wind River watershed and the Lander area of Popo Agie watershed.

> In each area there is a checkered ownership pattern of comparatively small farms or ranch units, widely scattered state lands, private land holdings, and isolated small public domain tracts. The Federal lands are about impossible to administer effectively because of the complex land ownership pattern.

In the projected Boysen Reservoir area, the eventual flooding of base properties and the reduction in public grazing area will necessitate some local adjustments in the grazing economy. Intra-agency collaboration should be sought in planning for such recreation and wildlife assets as the Boysen Reservoir will enable.

Irrigators and ranchers, engineers and land managers, by virtue of the unity of nature must work together in watershed control and full resources development. Area study offers the cheapest and only practical basis for obtaining the information needed to bring about solutions to the basin-wide problems and to other problems of primary concern to the lands under the custody of the Bureau of Land Management. The high cost of bringing about fullest productive use of range lands and maximum watershed values and solutions to other land problems is, in part, the price which must now be paid for allowing land use problems, inherently difficult, to be neglected until they have become in some areas acute and expensive to remedy.

END

June 11, 1947

APPENDIX I

Soils 1/

Soils Generally Under Irrigation

Wind River Series occurs on level benches and terraces, on alluvial fans and valley fill, and on fluviatile material on level-topped ridges and buttes in all parts of the surveyed areas. It usually has a 6 to 9 inch lime-free brown topsoil beneath a gray friable surface mulch and a gravelly substratum generally at about 3 feet which insures good drainage of the lighter types. The loam type is the best irrigated soil of the area. Gravelly and stony loam phases which are more difficult to cultivate occur in the vicinity of Wind River and Fort Washakie. Non-extensive heavier-textured types derived from outwash of shale material become alkaline and seepy if not irrigated and handled properly. On shallow profiled sandier types, much water may be lost through the gravel horizon if water runs are too long. Rolling phase of gravelly fine sandy loam is generally used for grazing. According to crop productivity and cultivability, loam and fine sandy loam types rate as first class soils, seeped or gravelly loams as second class, and poorly drained alkali areas and clay loam, clay, and stony loam as third or fourth class. Main crops grown are alfalfa, oats, beans, and wheat with some sugar beets, barley and corn.

Ethete Series 2/ occur on lower level terraces, generally on more recent alluvial deposits with gravel more or less diffused throughout the profile. Typically, the surface mulch is gray with a slightly brownish-gray root horizon 5 to 7 inches deep overlying compact heavier material to 16 to 18 inches and a more friable substratum beneath. Much of the soil is calcareous from the surface downward. Sandier types are considered good quickly irrigable soils, the heavier types difficult to reclaim and work when impregnated with alkali. The fine sandy loam type is extensively developed on the older irrigated terraces north and west of Riverton along the north and west sides of Wind River. Fine sand type used mainly for pasture occurs on small sand dunes of the bottom lands along Wind River. Ethete loam, one of the more extensive gray irrigated soils is most extensive north of Riverton, between Riverton and Hudson, and east of Pavillion. The rolling phase is generally used for grazing. Clay loam prevails in fairly large bodies east of Pavillion, north and west of Riverton, about Ocean Lake, south of Lander, near Milford, and at Ethete. Silt loam and clay types exist only in isolated patches. Fine sandy loam, loam, and silt loam types are graded as first class soils, clay loams as second class, clay as third class, and fine sand as fourth class. Main crops produced include alfalfa, wheat, oats, barley, beans, corn, beets, and potatoes.

Chugwater Series 2/, distinguished by its reddish color, developed on sandstones, limestones, and alluvial materials of similar nature chiefly in

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1/ Abstracted from Dunnewald, T. J., Williams, Orel, and Stevens, Delvin, Soil survey of Lander-Riverton area, Fremont County, Wyoming: Wyoming soil survey (manuscript report in files Dept. of Agronomy, Univ. of Wyoming), 1932.

2/ Field name not yet passed upon by Correlation Committee.

a band close to the mountains west of Lander. About 18 to 20 inches of very fertile calcareous soils have generally formed on the parent materials, but being situated among the steeply inclining beds at the base of the mountains they are in most instances difficult to water and cultivate. Erosion by wind and water is a serious factor in their use. Pasture and permanent cover crops appear best adapted to this series. Fine sandy loam occupies non-extensive areas of undulating relief, the rolling and level portions being separated as rolling and level phases. The heavier and more productive loam type occurs most extensively along Mill Creek and south of Ray Lake where it occupies an old greasewood flat in which soluble salts have puddled the soil. Clay loam, level phase, is a tough and compact type near Lander used for garden truck, grain, alfalfa, and hay. Rolling phases of these soils are usually not irrigated. Fine sandy loam, its level phase, and loam rate as first grade soils; rolling phase fine sandy loam, rolling phase and level alluvial phase loams, and level phase clay loam rank as second grade. Chugwater soils produce high quality grains, potatoes, and alfalfa.

Soils Generally Used for Grazing

Arapahoe Series 2/ includes the shallow soils derived from grayish to black shales on rolling country. Sandy shales have generally developed brown-colored soil profiles of 14 to 16 inches and heavier drab or black clay shales a more gray or drab-colored, shallower, less fertile soil of clay loam or clay texture. The latter shale soils are apt to contain more soluble alkali salts and be characterized by poor drainage, salt accumulations, sticky cold soil hard to handle, and stunted plant growth. Rolling topography and proximity to saline shales should limit these soils mainly to pasture use, with irrigation, when practiced, careful to prevent seep, alkali accumulation, and erosion. Loam areas are quite extensive and occur chiefly in the vicinity of Lander, Hudson and Ethete. The rolling phase occurs chiefly as scattered strips and patches on steep, rolling, or eroded slopes adjoining rough stony land. Travertine silt loam, a non-cultivable soil surrounds the hot springs northeast of Fort Washakie. Largest blocks of clay loam, much of which lies above present irrigation, occur around Ray Lake, along the mountains west and south of Lander, and southeast of Hudson. The shallow, heavy, immature clay type found mainly south of Arapahoe and Lander is difficult to utilize and not very productive. Arapahoe loam and clay are graded as the best soils, loam (rolling phase) as second grade, and travertine silt loam, clay loam (rolling phase), clay, and clay (rolling phase) as poor soils.

Saddle Series 2/ are residual soils developed mainly on sandstone on undulating to smooth uplands of the Wind River formation. Their profile is the most mature and developed of any of the series in the area and typically includes a grayish-brown surface crust, light gray friable mulch, light brown compact topsoil down to 9 to 12 inches, and grayish-brown subsoil (B) to about 24 inches. These soils are adapted to farming, but large bodies lie above irrigation or are beyond the reach of canals and so will no doubt always be used for grazing.

2/ Field name not yet passed upon by Correlation Committee.

The more sandy and shallower types should be kept to grazing use as they tend to wind erosion and are wasteful of irrigation water. Fine sandy loam is an extensive type, the larger bodies appearing about the vicinity of Hudson and paralleling the mountains across the irrigation projects where much of the soil is being developed into farms. The rolling phase occupies steeper slopes, ridges, and knolls and is best adapted to pasture and grazing. Fine sand type which prevails on the rougher Wind River conglomerate and in largest bodies north of Five Mile Creek is a poor soil for crop and irrigation purposes. Fine sandy loam rates first class and its rolling phase second class. Alfalfa, beans, corn, potatoes, sugar beets, wheat, barley, and oats all do well on these soils.

Laurel and Harlem Soils include the first bottom soils along the streams where high water stages cause flooding and deposition of variable amounts and kinds of alluvial material. In general, the bottom-land soil is dark brown to black in color near the mountains and in smaller stream bottoms where greater moisture has encouraged denser vegetative growth and more gray in color along the larger streams and farther away from the mountains. The dark soils have been placed in the Harlem series, while the lighter ones are classified as Laurel soils. Brushy sloughs, channels, and open grass and sage meadows are interspersed with a rather dense growth of cottonwood trees. As cultivation is difficult due to frequent inundation and alkali accumulation with irrigation of higher slopes, these areas should probably be confined to pasture. Laurel loam, Harlem loam, and Harlem silt loam are similar in location and usefulness for sheltered winter pasture, source of firewood and materials for fences, corrals, and buildings, wild hay crops, and gardens. All types rate as second grade soils.

Rough Broken Land includes rock ledges, outcrops, steep stony and gravelly slopes, and all other land too rough and stony for cultivation. There is very little soil cover in these areas on which forage can grow.

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